Stanford Project: RX--DERIVING KNOWLEDGE FROM TIME-ORIENTED CLINICAL DATABASES

Principal Investigators: Robert L. Blum, M.D.
Departments of Medicine
and Computer Science
Stanford University
Stanford, California 94305
(415) 497-3088 (BLUM@SUMEX-AIM)

Gio C.M. Wiederhold, Ph.D.
Departments of Computer Science
and Electrical Engineering
Stanford University
Stanford, California 94305
(415) 497-0635 (WIEDERHOLD@SUMEX-AIM)

The objective of clinical database (DB) systems is to derive medical knowledge from the stored patient observations. However, the process of reliably deriving causal relationships has proven to be quite difficult because of the complexity of disease states and time relationships, strong sources of bias, and problems of missing and outlying data.

The goal of the RX Project is to explore the usefulness of knowledge-based computational techniques in solving this problem of accurate knowledge inference from non-randomized, non-protocol patient records. Central to RX is a knowledge base (KB) of medicine and statistics, organized as a taxonomic tree consisting of frames with attached data and procedures. The KB is used to retrieve time-intervals of interest from the DB and to assist with the statistical analysis. Derived knowledge is incorporated automatically into the KB. The American Rheumatism Association DB containing 7,000 patient records is used.

SOFTWARE AVAILABLE ON SUMEX

RX--(excluding the knowledge base and clinical database) consists of approximately 200 INTERLISP functions. The following groups of functions may be of interest apart from the RX environment:

SPSS Interface Package: Functions which create SPSS source decks and read SPSS listings from within INTERLISP.
Statistical Tests in INTERLISP: Translations of the Piezer-Pratt approximations for the T,F, and Chi-square tests into LISP.
Time-Oriented Data Base and Graphics Package: Autonomous package for maintaining a time-oriented database and displaying labelled time-intervals.

REFERENCES

Blum, R.L. and Wiederhold, G.: Inferring knowledge from clinical data banks utilizing techniques from artificial intelligence. Proc. Second Annual Symposium Computer Applications in Medical Care, IEEE, Washington, D.C., November, 1978, pp. 303-307.

Blum, R.L.: Automating the study of clinical hypotheses on a time-oriented database: The RX project. Submitted to MEDINFO80, Third World Conference on Medical Informatics, Tokyo, 1980.

Weyl, S., Fries, J., Wiederhold, G. and Germano, F.: A modular self-describing clinical databank system. Comp. and Biomed. Res. 8(3):279-293, June, 1975.

Wiederhold, G., Fries, J.F.: Structured organization of clinical data bases. AFIPS Conference Proc. 44:479-485, 1975.

Appendix B

AI Handbook Outline

E. A. Feigenbaum and A. Barr
Computer Science Department
Stanford University

This is a list of the Chapters in the Handbook. Articles in the first five Chapters appear in Volume I. Articles in Chapters VI through X will appear in Volume II, and the remaining chapters are expected to appear in Volume III. A list of all of the articles in each Chapter (although tentative for Volume III) follows.

VOLUME I:

I. Introduction
II. Search
III. Knowledge Representation
IV. Understanding Natural Language
V. Understanding Spoken Language

VOLUME II:

VI. Programming Languages for AI Research
VII. Applications-oriented AI Research: Science
VIII. Applications-oriented AI Research: Medicine
IX. Applications-oriented AI Research: Education
X. Automatic Programming

VOLUMES III (Tentative):

XI. Models of Cognition
XII. Automatic Deduction
XIII. Vision
XIV. Robotics
XV. Learning and Inductive Inference
XVI. Planning and Problem Solving

VOLUME I

I. INTRODUCTION

- A. What is Artificial Intelligence?
- B. The AI Handbook
- C. Accessing the AI literature

II. SEARCH

- A. Overview
- B. Problem representation
  - 1. State-space representation
  - 2. Problem-reduction representation
  - 3. Game trees
- C. Search methods
  - 1. Blind state-space search
  - 2. Blind AND/OR graph search
  - 3. Heuristic state-space search
    - a. Basic concepts in heuristic search
    - b. A*--Optimal search for an optimal solution
    - c. Relaxing the optimality requirement
    - d. Bidirectional search
  - 4. Heuristic search of an AND/OR graph
  - 5. Game tree search
    - a. Minimax procedure
    - b. Alpha-beta pruning
    - c. Heuristics in game tree search
- D. Sample search programs
  - 1. Logic Theorist
  - 2. General Problem Solver
  - 3. Gelernter's geometry theorem-proving machine
  - 4. Symbolic integration programs
  - 5. STRIPS
  - 6. ABSTRIPS

III. KNOWLEDGE REPRESENTATION

- A. Overview
- B. Survey of representation techniques
- C. Representation schemes
  - 1. Logic
  - 2. Procedural representations
  - 3. Semantic networks
  - 4. Production systems
  - 5. Direct (analogical) representations
  - 6. Semantic primitives
  - 7. Frames and scripts

IV. UNDERSTANDING NATURAL LANGUAGE

A. Overview
B. Machine translation
C. Grammars
   1. Review of formal grammars
   2. Transformational grammars
   3. Systemic grammar
   4. Case grammars
D. Parsing
   1. Overview of parsing techniques
   2. Augmented transition networks
   3. The General Syntactic Processor
E. Text generation
F. Natural language processing systems
   1. Early natural language systems
   2. Wilks's machine translation system
   3. LUNAR
   4. SHRDLU
   5. MARGIE
   6. SAM and PAM
   7. LIFER

V. UNDERSTANDING SPOKEN LANGUAGE

A. Overview
B. Speech systems architecture
C. The ARPA SUR projects
   1. HEARSAY
   2. HARPY
   3. HWIM
   4. The SRI/SDC speech systems

VOLUME II

VI. PROGRAMMING LANGUAGES FOR AI RESEARCH

A. Historical overview
B. Features of AI programming languages
   1. Overview and comparison
   2. Data structures
   3. Control structures
   4. Pattern matching
   5. Programming environment
   6. Truth maintenance
C. Major AI programming languages
   1. LISP
   2. PLANNER and CONNIVER
   3. QLISP
   4. SAIL
   5. POP-2
   6. FUZZY

VII. APPLICATIONS-ORIENTED AI RESEARCH: SCIENCE

- A. Overview of applications-oriented AI research
- B. TEIRESIAS--Issues in designing expert systems
- C. Research on applications in chemistry
  - 1. Applications in chemical analysis
  - 2. The DENDRAL programs
    - a. DENDRAL
    - b. CONGEN and its extensions
    - c. Meta-DENDRAL
  - 3. CRYSALIS
  - 4. Applications in organic synthesis
- D. Other scientific applications
  - 1. MACSYMA
  - 2. The SRI computer-based consultant
  - 3. PROSPECTOR
  - 4. AI in database management

VIII. APPLICATIONS-ORIENTED AI RESEARCH: MEDICINE

- A. Overview
- B. Medical applications systems
  - 1. MYCIN
  - 2. CASNET
  - 3. INTERNIST
  - 4. Present Illness Program
  - 5. Digitalis Advisor
  - 6. IRIS
  - 7. EXPERT

IX. APPLICATIONS-ORIENTED AI RESEARCH: EDUCATION

- A. Historical overview of AI applications in education
- B. Issues in the design of tutoring systems
- C. Computer-based tutoring systems
  - 1. SCHOLAR
  - 2. WHY
  - 3. SOPHIE
  - 4. WEST
  - 5. WUMPUS
  - 6. GUIDON
  - 7. BUGGY
  - 8. EXCHECK
- D. Research on nontutorial uses of AI in education

X. AUTOMATIC PROGRAMMING

- A. Overview--Methods of program specification

B. Basic approaches to automatic programming
C. Automatic programming systems
   1. PSI
   2. SAFE
   3. Programmer's Apprentice
   4. PECOS
   5. DAEDALUS
   6. PROTOSYSTEM-1
   7. NLPQ
   8. LIBRA--Automatic program optimization

VOLUME III (Tentative)

XI. MODELS OF COGNITION

A. Overview
B. General Problem Solver
C. Models of cognitive development
D. EPAM
E. Semantic-network models of memory
   1. Quillian's semantic memory system
   2. HAM
   3. ACT
   4. MEMOD
F. Belief systems

XII. AUTOMATIC DEDUCTION

A. Overview
B. Resolution-based theorem proving
C. Nonresolution theorem proving
D. Applications of theorem proving
E. Nonmonotonic logic

XIII. VISION

A. Overview
B. Blocks-world understanding
C. Processing of visual data
D. Shape understanding
E. Representation and control methods in vision
F. Sample applications in vision research

XIV. Robotics

A. Overview
B. Computation in a physical environment
C. Engineering and kinematics
D. Languages and simulation
E. Planning and representation

XV. Learning and Inductive Inference

- A. Overview
- B. Rote learning
- C. Advice taking
- D. Learning from examples
  1. Overview
  2. Adaptive learning
  3. Learning single concepts
  4. Learning multiple concepts
  5. Learning by doing

XVI. Planning and Problem Solving

- A. Overview
- B. Linear planners
- C. Hierarchical planners
  1. NOAH and extensions
  2. MOLGEN
- D. Opportunistic planning

Appendix C

AIM Management Committee Membership

The following are the membership lists of the various SUMEX-AIM management committees at the present time:

AIM Executive Committee:

LEDERBERG, Joshua, Ph.D. (Chairman)
President
The Rockefeller University
1230 York Avenue
New York, New York 10021
(212) 360-1234, 360-1235

AMAREL, Saul, Ph.D.
Department of Computer Science
Rutgers University
New Brunswick, New Jersey 08903
(201) 932-3546

BAKER, William R., Jr., Ph.D. (Exec. Secretary)
Biotechnology Resources Program
National Institutes of Health
Building 31, Room 5B43
9000 Rockville Pike
Bethesda, Maryland 20205
(301) 496-5411

FEIGENBAUM, Edward, Ph.D.
Principal Investigator - SUMEX
Department of Computer Science
Margaret Jacks Hall, Room 216
Stanford University
Stanford, California 94305
(415) 497-4079

LINDBERG, Donald, M.D. (Adv Grp Member)
605 Lewis Hall
University of Missouri
Columbia, Missouri 65201
(314) 882-6966

MYERS, Jack D., M.D.
School of Medicine
Scaife Hall, 1291
University of Pittsburgh
Pittsburgh, Pennsylvania 15261

SHORTLIFFE, Edward H., M.D., Ph.D.
Co-Principal Investigator - SUMEX
Division of General Internal Medicine, TC117
Stanford University Medical Center
Stanford, California 94305
(415) 497-5821

AIM Advisory Group:

LINDBERG, Donald, M.D. (Chairman)
605 Lewis Hall
University of Missouri
Columbia, Missouri 65201
(314) 882-6966

AMAREL, Saul, Ph.D.
Department of Computer Science
Rutgers University
New Brunswick, New Jersey 08903
(201) 932-3546

BAKER, William R., Jr., Ph.D. (Exec. Secretary)
Biotechnology Resources Program
National Institutes of Health
Building 31, Room 5B43
9000 Rockville Pike
Bethesda, Maryland 20205
(301) 496-5411

FEIGENBAUM, Edward, Ph.D. (Ex-officio)
Principal Investigator - SUMEX
Department of Computer Science
Margaret Jacks Hall, Room 216
Stanford University
Stanford, California 94305
(415) 497-4079

LEDERBERG, Joshua, Ph.D.
President
The Rockefeller University
1230 York Avenue
New York, New York 10021
(212) 360-1234, 360-1235

MINSKY, Marvin, Ph.D.
Artificial Intelligence Laboratory
Massachusetts Institute of Technology
545 Technology Square
Cambridge, Massachusetts 02139
(617) 253-5864

MOHLER, William C., M.D.
Associate Director
Division of Computer Research and Technology
National Institutes of Health
Building 12A, Room 3033
9000 Rockville Pike
Bethesda, Maryland 20205
(301) 496-1168

MYERS, Jack D., M.D.
School of Medicine
Scaife Hall, 1291
University of Pittsburgh
Pittsburgh, Pennsylvania 15261
(412) 624-2649

PAUKER, Stephen G., M.D.
Department of Medicine - Cardiology
Tufts New England Medical Center Hospital
171 Harrison Avenue
Boston, Massachusetts 02111
(617) 956-5910

SHORTLIFFE, Edward H., M.D., Ph.D. (Ex-officio)
Co-Principal Investigator - SUMEX
Division of General Internal Medicine, TC117
Stanford University Medical Center
Stanford, California 94305
(415) 497-5821

SIMON, Herbert A., Ph.D.
Department of Psychology
Baker Hall, 339
Carnegie-Mellon University
Schenley Park
Pittsburgh, Pennsylvania 15213
(412) 578-2787 or 578-2000

Stanford Community Advisory Committee:

FEIGENBAUM, Edward, Ph.D. (Chairman)
Department of Computer Science
Margaret Jacks Hall, Room 216
Stanford University
Stanford, California 94305
(415) 497-4079

SHORTLIFFE, Edward H., M.D., Ph.D.
Co-Principal Investigator - SUMEX
Division of General Internal Medicine, TC117
Stanford University Medical Center
Stanford, California 94305
(415) 497-5821

DJERASSI, Carl, Ph.D.
Department of Chemistry, Stauffer I-106
Stanford University
Stanford, California 94305
(415) 497-2783

MAFFLY, Roy H. Maffly, M.D.
Division of Nephrology
Veterans Administration Hospital
3801 Miranda Avenue
Palo Alto, California 94304
(415) 858-3971

References

1. Feigenbaum, E.A., The Art of Artificial Intelligence: Themes and Case Studies of Knowledge Engineering, Proceedings of the 1978 National Computer Conference, AFIPS Press, (1978).

2. Nilsson, N.J., Principles of Artificial Intelligence, Tioga Publishing Company, Palo Alto, California (1980).

3. Winston, P.H., Artificial Intelligence, Addison-Wesley Publishing Co., (1977).

4. Nilsson, N.J., Artificial Intelligence, Information Processing 74, North-Holland Pub. Co. (1975).

5. Barr A. and Feigenbaum, E.A. (Eds.), The Handbook of Artificial Intelligence Volume I, William Kaufmann, Inc. Los Altos, Calif. (1981)

6. Boden, M., Artificial Intelligence and Natural Man, Basic Books, New York, (1977).

7. McCorduck, P., Machines Who Think, W.H. Freeman and Co., San Francisco (1979).

8. Coulter, C. L., Research Instrument Sharing, Science, Vol. 201, No. 4354, August 4, 1978.

9. Metcalfe, R.M. and Boggs, D.R., Ethernet: Distributed Packet Switching for Local Computer Networks, Comm. ACM, Vol. 19, No. 7 (July 1976).

10. Shoch, J.F. and Hupp, J.A., Performance of an Ethernet Local Network -- A Preliminary Report, Proceedings of the Local Area Communications Network Symposium, Boston,May 1979.

11. Taft, E.A., Implementation of PUP in TENEX, Internal XEROX PARC memorandum, June 1978.

12. Boggs, D.R., Shoch, J.F., Taft, E.A., and Metcalfe, R.M., PUP: An Internetwork Architecture, XEROX PARC report CSL-79-10, July 1979.

13. Digital Equip. Corp., Intel Corp., and Xerox Corp., The Ethernet - Data Link and Physical Layer Specifications, Version 1.0, September 30, 1980.